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Studies of nanoflagellates in sea ice of the Baltic and Greenland Sea

Protist communities in the Baltic and Greenland Sea ice were surveyed with particular emphasis on nanoflagellate communities. The studies were made along the Finnish coast of the Baltic Sea and in the northern Greenland during 1994-96. Study material consisted of ice, brine and water samples. Sampling programme for collecting different stages of newly forming and young ice and aimed for the study of protist incorporation was performed in the Greenland Sea. For examining the flagellate species composition in shallow meltwater ponds on Greenland Sea ice and comparing it with the community in an Arctic landpond, samples were collected in the Northeast Water Polynya (79-81°N/10-17°W).

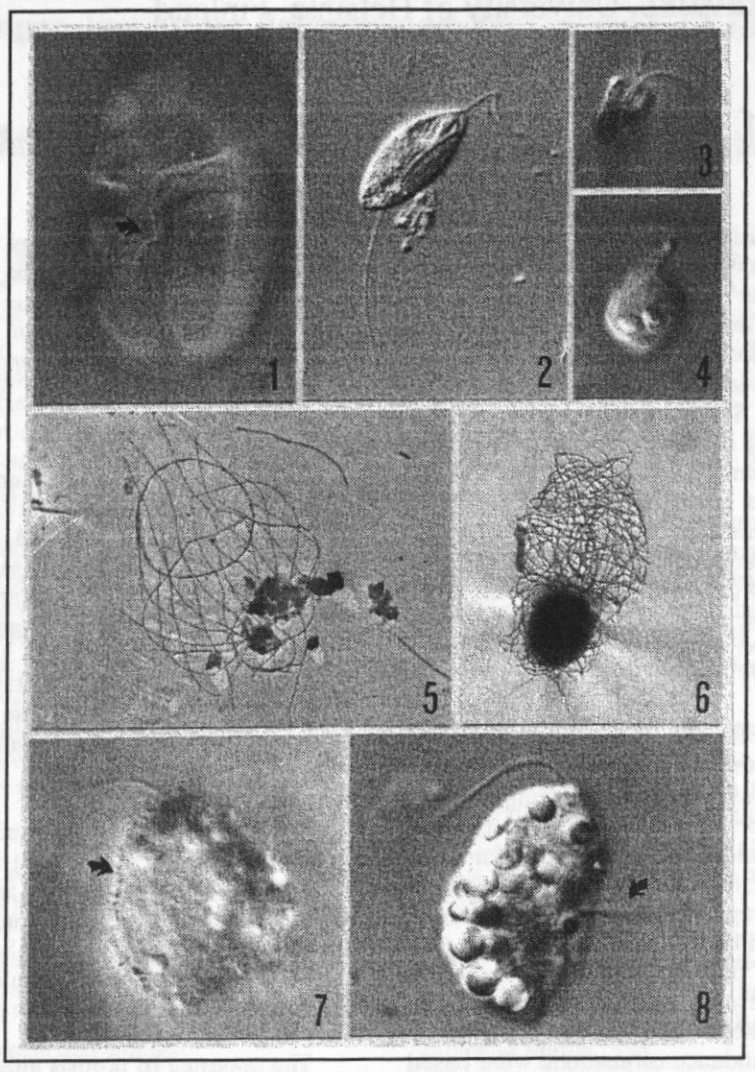
Live material was examined by means of light microscope fitted with interference optics. Documentation of flagellate swimming, feeding and reproduction was made by photographic and video technique. Whole mounts for light (LM) and transmisson electron microscopy (TEM) were prepared onboard and examined later. This provided information about the fine structure of in particular scale-bearing organisms. Epifluorescence microscopy was used to differentiate photo- and heterotrophic organisms. Cell abundance estimations were based on cell countings from sedimented samples examined with an inverted microscope.

The Baltic Sea ice is inhabited by microbial communities which are best described by the dominance of diatoms, both in terms of number of taxa and cell abundance, and by the diversity of photo- and heterotrophic nanoflagellates (Fig. 1-8). Almost all presently known flagellate groups are present in the Baltic Sea ice biota, where choanoflagellates (Fig. 5+6), dinoflagellates (Fig. 1), cryptophytes, chrysophytes, prasinophytes (Fig. 3) and protists of uncertain systematic affinity (Fig. 4, 7, 8) are common. The green alga *Monoraphidum contortum* had coloured the ice bright green in the Bothnian Bay (northern Baltic Sea) in March 1994, where also distinct protist communities in different layers in the ice were detected. The high abundance of heterotrophic protists like peduncle feeding dinoflagellates (Fig. 1) or the ice flagellate *Cryothecomonas armigera* (Fig 8) point towards an active microbial food cycling inside the sea ice.

As a result of the ordination of nanoflagellate communities we can conclude, that flagellate communities encountered in ice and water samples from the Baltic Sea form two distinct groups. Furthermore, the variation in regard to the flagellate species composition in different habitats (ice versus water) is stronger than the geographical (Bothnian Bay versus southern coast of Finland) one. These results are largely explained by the higher number of flagellate taxa encountered in the ice.

A significant degree of similarity between the Baltic and Greenland Sea ice nanoflagellate communities is evident. In addition to the commonly encountered groups in the Baltic Sea, the ice biota in the Greenland Sea is characterized by the generality of chlorophytes, heterotrophic euglenids and dinoflagellate resting stages.

The presence of protists already in the first stages of new ice formation is documented. The grade of selectivity in the incorporation process is, however, largely unknown. Our results from the Greenland Sea showed that 1) both biomass and number of protist taxa in the sea ice is often higher than in the water column, and 2) incorporation is by large a passive process and displays different incorporation rates for different protist groups. The highest incorporation rates were observed for diatoms, the lowest for heterotrophic flagellates and bacteria. We assume that this is primarily due to the large size of diatom cells in relation to nanoflagellates and bacteria, which increases the probability of these algal cells to become trapped in the forming ice. Secondly, being capable of swimming flagellates may actively move in and out of ice.



Legends to figures 1.-8.
Examples of nanoflagellates in Baltic Sea ice and plankton.
Fig.1. Heterotrophic gymnodinioid flagellate. The peduncle for prey capture is marked with an arrow.
Fig.2. Euglenoid flagellate (*Anisonema* sp.).
Fig.3. Prasinophycean flagellate *Pyramimonas* sp.
Fig.4. *Telonema subtile* (Protista incertae sedis).
Fig.5. *Diaphanoeca sphaerica* (Choanoflagellida).
Fig.6. *Stephanoeca urnula* (Choanoflagellida).
Fig.7. *Cryothecomonas scybalophora* (Protista incertae sedis). Note the mineral particles attached onto the cell surface (arrow).
Fig.8. *Cryothecomonas armigera* (Protista incertae sedis). Note the pseudopod for particle capture (arrow). Magnifications: LM figs. 1.-4., 7.-8. 2000x, TEM fig.5. 1500x, TEM fig.6. 2400x.

The diversity of scale-bearing and loricate nanoflagellates in shallow meltwater ponds in the Arctic proved to be relatively low. The single landpond studied, which acted as a reference, displayed a significantly higher number of taxa compared to the meltponds. Two new chrysophyte species were found and described. The scarcity of armoured nanoflagellates in our study does not necessarily mean, however, that these organisms would not exist in Arctic meltponds. Assumably a number of factors, e.g. time of sampling and patchiness, have resulted to the low number of taxa we encountered.

Some of the main topics for future studies of the Baltic Sea ice biota are the origin of the organisms and mechanisms of incorporation into the ice, temporal and spatial variation of protist communities, as well as the abundance and role of key-species and the energy transfer between functional groups in the ice and the pelagial.

The text is based on the following publications of the author:

IKÄVALKO, J. (1998): Further observations on flagellates within sea ice in the northern Bothnian Bay, the Baltic Sea. - Polar Biol. (in press)

IKÄVALKO, J.: Microbial communities in sea ice. - Memoranda Soc. Fauna Flora Fennica (submitted)

IKÄVALKO, J. & THOMSEN, H. A. (1997): The Baltic Sea ice biota (March 1994): study of the protistan community. - Europ. J. Protistol. 33: 229-243

IKÄVALKO, J. & THOMSEN, H. A. (1996): Scale-covered and loricate flagellates (Chrysophyceae and Synurophyceae) from the Baltic Sea ice. - Beih. Nova Hedwigia 114: 147-160

IKÄVALKO, J. & THOMSEN, H. A. (1995): Baltic Sea ice biota (March 1994): remarks on the occurrence and abundance of *Cryothecomonas armigera* (Protista incertae sedis) and C. scybalophora. - Europ. J. Protistol. 31: 113

IKÄVALKO, J., THOMSEN, H.A. & CARSTENS, M. (1996): A preliminary study of NE Greenland shallow meltwater ponds with particular emphasis on loricate and scale-covered forms (Choanoflagellida, Chrysophyceae sensu lato, Synurophyceae, Heliozoea), including the descritions of *Epipyxis thamnoides* sp. nov. and *Pseudokephyrion poculiforme* sp. nov. (Chrysophyceae). - Arch. Protistenkd. 147: 29-42

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